A Survey of Knowledge Management Research & Development at NASA Ames Research Center

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Abstract

This chapter catalogs knowledge management research and development activities at NASA Ames Research Center as of April 2002. A general categorization scheme for knowledge management systems is first introduced. This categorization scheme divides knowledge managemnt capabilities into five broad categories: knowledge capture, knowledge preservation, knowledge augmentation, knowledge dissemination, and knowledge infrastructure. Each of nearly 30 knowledge management systems developed at Ames is then classified according to this system. Finally, a capsule description of each system is presented along with information on deployment status, funding sources, contact information, and both published and internet-based references.

Keywords: knowledge management software, knowledge management classification schemes, NASA technology, information repositories, information integration

1. Introduction

Ames Research Center is NASA's Center of Excellence for Information Technology, and Ames conducts research and development activities in many different technology areas, including knowledge management (KM). Wherever possible, NASA utilizes commercial knowledge management systems to meet its internal needs. However, commercial systems do not always satisfactorily address the specialized needs of NASA programs and missions. Under these circumstances NASA conducts research and develops targeted knowledge management systems, primarily for internal use. Ames Research Center has taken the lead on developing many of the agency's innovative knowledge management systems.

Historically, Ames has been active in KM-related research and development since the late 80,'s well before the term *knowledge management* was coined. One research discipline closely related to KM is artificial intelligence, and AI has long been a focal area of computer science research at Ames (Friedland, 1990). Although research in AI has a different focus than research in KM, there are many overlapping concerns. Knowledge management research focuses on methods of facilitating knowledge transfer from individual to individual within an organization, with the goal of improving individual and organizational performance. Technology may or may not be part of the knowledge transfer process. In contrast, AI focuses on knowledge transfer from human to computer, and on automated techniques for utilizing knowledge to reason and solve problems. In AI, the computer plays a central role, whereas in KM, the computer is simply one means of achieving knowledge transfer. Despite these differences, computer representation and use of knowledge are core concerns of both AI and KM. In addition, *knowledge capture* (also referred to as *knowledge acquisition* (Buchanan & Wilkins, 1992) or *machine learning* (Mitchell, 1997)) is an area of intersecting concern for both research areas.

This chapter provides a survey of knowledge management research and development activities at Ames Research Center. Most of the projects and systems reviewed were ongoing as of early 2002, but some prominent legacy efforts are also reviewed. Although this survey is comprehensive, we make no claims regarding completeness. We begin with a framework for classifying knowledge management systems, and then describe and classify nearly 30 of Ames' knowledge management systems based on this framework. Finally, we present a capsule summary of each system, along with information on deployment status, funding sources, contact information, and both published and internet-based references.

2. Classifying Ames' Knowledge Management R&D Activities

For purposes of classification, we divide knowledge management capabilities into five broad categories: 1) capture, 2) preservation, 3) augmentation, 4) dissemination, and 5) infrastructure. Although individual systems may provide capabilities that cross several of these categories, most systems can be characterized in terms of providing primary capabilities corresponding to one or at most two of these categories. In discussing knowledge management and categorizing these systems, I take an inclusive viewpoint on the subject of what constitutes "knowledge" and avoid making sharp distinctions among the terms "knowledge", "information", and "data". Each broad knowledge management capability category is further subdivided into several finer-grained subcategories.

1) Knowledge capture

Capture systems provide a means of acquiring knowledge from individuals and storing it in a computer-compatible representation. Included in this category are:

a) **Meeting capture systems** - These systems support capture of knowledge from meetings in the form of audio, video, written transcripts, notes, agenda items, whiteboard sketches, action item lists, and computer files.

b) **Design capture systems** - These systems capture knowledge as a by-product of the engineering design process, including knowledge within design requirements, sketches, engineering drawings, and design rationale documents.

c) **Knowledge acquisition systems** - This is a broad category of systems designed to acquire knowledge from experts by means of a variety of techniques and methodologies, including repertory grids, expert systems, and inference.

2) Knowledge preservation

Preservation systems provide storage for a body of knowledge, along with functionality for accessing and searching the knowledge. Included in this category are:

a) **Repository systems** - These systems include document and data management systems that store enterprise-related information.

b) **Organizational memory systems** - These systems provide a record of past organizational actions and decision-making processes. Included here would be email archiving and threading services, decision-archiving systems, project information stores, workflow systems, and information-tracking systems.

c) **Lessons learned systems** - These systems store lessons learned during the conduct of enterprise operations and provide methods of searching, accessing, and delivering lessons to relevant personnel.

d) **FAQ systems** - These systems provide answers to frequently-asked questions relevant to the conduct of enterprise business.

3) Knowledge augmentation

Augmentation systems focus on deriving value-added information on top of existing knowledge, in the form of annotation or meta-knowledge. Included in this category are:

a) **Knowledge mining systems** - Knowledge/data mining systems discover undetected patterns in stored information.

b) **Knowledge integration systems** - These systems combine data from heterogeneous sources to provide an integrated body of information that is greater than the sum of the parts.

c) **Descriptive metadata systems** - Metadata systems provide mechanisms for describing the structure of knowledge, in the form of specialized taxonomies and ontologies.

4) Knowledge dissemination

Dissemination systems focus on timely delivery of knowledge to individuals who may require or benefit from the information in conducting their work tasks. Included in this category are:

a) **Expertise locator systems** - These systems assist users in finding individuals within the organization who possess desired skills or expertise.

b) **Portal systems** - Portals provide a user-customizable view of enterprise knowledge resources, typically delivered as a Web page.

c) **Newsletters** - Newsletters (in either electronic or print format) provide for regular dissemination of knowledge to a targeted enterprise readership at regular intervals.

d) **Agent systems** - Agents are programs that can actively notify users or act on behalf of users when information relevant to their current task or area of responsibility is added or modified within the enterprise knowledge store.

e) **Collaboration and meeting support systems** - These systems enable people to communicate and interchange information over distances.

5) Knowledge infrastructure

Knowledge infrastructure pertains to the supporting technology necessary to build and operate knowledge management systems. Included in this category are:

a) **Knowledge modeling / representation systems** - These systems provide the building blocks for storing and reasoning about knowledge in AI systems, workflow systems, deductive database systems.

b) **Indexing and search systems** - These systems enable rapid access to information stored in knowledge repositories.

c) **Standards development** - Technical standards are important in many areas that affect knowledge sharing and management, including repository interoperability and data interchange.

d) **Networks** - High-speed computer networks provide the pathways over which data and information can be transmitted.

e) **Security** - Secure technologies, including encryption and authentication schemes, are essential for preserving the privacy and integrity of knowledge and data.

f) **Methods** - Various techniques and methodologies for system design and analysis are essential for developing effective knowledge management tools. These include participatory design and ethnographic methods, such as participant observation, video analysis, and interviewing.

Table 1 categorizes knowledge management systems developed at Ames Research Center according to the above classification system. Many of these systems provide knowledge management functionality that spans several subcategories. Table 1, however, reflects the author's subjective assessment of the primary knowledge management capabilities provided by each system. Although Ames does not have ongoing work in all of the defined subcategories, each of the top-level categories covers one or more systems. Half of Ames' systems fall into one of two subcategories: the repository system subcategory (9 of 29 systems) or the knowledge integration category (6 of 29 systems).

Table 1: Knowledge Management Systems developed at Ames Research Center

			Capture			Preserve				Augment			Disseminate					Infrastructure					
#	KM System	Status	a	b	c	a	b	c	d	a	b	c	a	b	c	d	e	a	b	c	d	e	f
1	Dedal	P;L		■																			
2	IMAGEbot	P			■						■												
3	Postdoc	D				■																	
4	CORE	P				■																	
5	ScienceOrganizer	D				■	■											■					
6	DARWIN	D				■																	
7	PDARS	D				■				■													
8	APMS	D				■				■													
9	Virtual Iron Bird	P				■																	
10	ASRS	D				■		■															
11	WebTagger	P				■													■				
12	Concept Maps	D					■											■					
13	Air Passenger Screening	C								■	■												
14	Perilog	D								■									■				
15	ADIS	P									■												
16	MPRS	D									■												
17	ISTKMS	P									■												
18	Aerospace Extranet	D									■										■		
19	Aviation Data Registry	P;L										■								■			
20	MER CIP	P												■									
21	CALLBACK	D													■								
22	DIAMS	P;L														■			■				
23	Brahms	D														■		■					
24	Office of the Future	C															■						
25	MERboard	P															■						
26	Information Power Grid	D																			■		
27	SAFE	D																			■	■	
28	NASA Astrobiology Inst.	n/a																					■
29	Technology Studies	n/a																					■

System status codes (as of April 2002) **C**: concept development **P**: prototype **D**: deployed **L**: legacy

This table, presents knowledge management systems developed at Ames Research Center, categorized according to the classification system described in the text. In the table, the systems are coded according to the categories that represent their primary focus areas:

- **Knowledge capture**: **a**) meeting capture systems; **b**) design capture systems; **c**) knowledge acquisition systems
- **Knowledge preservation**: **a**) repository systems; **b**) organizational memory systems; **c**) lessons learned systems; d) frequently-asked questions (FAQ) systems
- **Knowledge augmentation**: **a**) knowledge mining systems; **b**) knowledge integration systems; **c**) descriptive metadata systems
- **Knowledge dissemination**: **a**) expertise locator systems; **b**) portal systems; **c**) newsletters; **d**) agent systems; e) collaboration and meeting support systems
- **Knowledge infrastructure**: **a**) knowledge modeling/representation systems; **b**) indexing and search systems; **c**) standards development; **d**) networks; **e**) security; **f**) methods

3. Capsule System Descriptions

This section provides a capsule description of all systems listed in Table 1. Where relevant, each description includes information on the following:

- ***Classification***: Specifies system classification according to framework developed in Section 2 above.
- ***Deployment Status:*** Specifies where the system falls along a technology maturity spectrum.
  - *Concept development*: Only preliminary specifications or design plans completed.
  - *Prototype*: Prototype system implemented, but either no users or limited experimental usage.
  - *Deployed*: System deployed with real users on an ongoing basis.
  - *Inactive*: System is no longer under development.
- **Funding Source**: Specifies the primary NASA funding sources for the work. In some cases, funding programs that provided initial funding have been decommissioned or absorbed into new funding streams. The most current funding stream is listed. Generally, no funding is listed for inactive systems.
  - *CICT*: Computing, Information, and Communication Technologies Program
  - *ECS*: Engineering for Complex Systems Program
  - *AvSP*: Aviation Safety Program
  - *AOS*: Airspace Operations Systems Program
  - *NAI*: NASA Astrobiology Institute
  - *FAA*: Federal Aviation Administration
  - *CMEX*: Center for Mars Exploration discretionary funding
  - *IST*: Information Sciences and Technology Directorate discretionary funding
  - *CSD*: Computational Sciences Division discretionary funding
- ***URL:*** Web pointer to further information on the system. Some URLs may not be accessible outside NASA firewalls, but the majority are accessible to any viewer.
- ***References***: Published references to this work, if any.
- ***Point of Contact***: Person to contact for further information.

The numbering scheme below corresponds to the numbering of systems in Table 1. The system descriptions are grouped according to their assigned top-level knowledge management category. Systems with functionality that spans more than one top-level knowledge management category are described in the first applicable category below.

Knowledge Capture Systems

1. **Dedal :** This tool was developed to capture, store, and index knowledge about the engineering design process, as described in schematics, specification documents, notes, etc. Dedal employs a structure/function model of the artifact being designed, and users index design information based on this model to ensure rapid, precise retrieval of information.

   Classification: design capture system

   Deployment Status: prototype; inactive

   URL: http://ic.arc.nasa.gov/projects/dedal/

   References: (Baudin, Gevins, Baya, & Mabogunje, 1992)

Point of Contact: Catherine Baudin, cbaudin@kaidara.com

2. **IMAGEbot:** This is an automated system that uses AI planning techniques to automatically transform input data products into a desired output form based on user goals. For example, IMAGEbot can take several separate sensor data files in differing formats and transform them into a single properly scaled and integrated dataset. IMAGEbot records and tracks the steps by which the data transformation was accomplished, thus capturing data processing knowledge as a by-product of data integration.

   Classification: knowledge acquisition system; knowledge integration system

   Deployment Status: prototype

   Funding Source: CICT

   Point of Contact: Keith Golden, kgolden@email.arc.nasa.gov

Knowledge Preservation Systems

3. **Postdoc:** Postdoc is a Web-based document-sharing tool developed to support distributed collaboration. The system has been used at Ames and across the Agency since 1997, and has proven to be a very effective tool for organizing, storing, and retrieving documents of all types (e.g., word-processing, spreadsheet, presentation, image, video, audio, executables). Users can add, delete, organize, and share documents the way they want without the help of Webmasters or other technical professionals. Postdoc supports full-text document indexing, fine-grained document access control, mailing list management and archiving, subscription and notification services, document conversion services, and many other useful features. There are several thousand Postdoc users at Ames, other NASA centers, and other government agencies.

   Classification: repository system

   Deployment Status: deployed

   Funding Source: CSD

   URL: http://postdoc.arc.nasa.gov/

   References: (Keller et al., 1999)

   Point of Contact: Helen Stewart, hstewart@mail.arc.nasa.gov

4. **CORE:** The Complex Object Relationship Engine (CORE) is a software infrastructure for building collaborative applications, including document and data-sharing repositories. CORE provides a middleware layer that supports application-neutral data and property storage for repositories, and incorporates a flexible access control scheme with a relational database back-end. CORE was developed as an attempt to generalize the Postdoc system storage architecture (see #3 above).

   Classification: repository system

   Deployment Status: prototype

   Funding Source: CSD

   URL: https://postdoc.arc.nasa.gov/core

   Point of Contact: Chris Knight, cknight@mail.arc.nasa.gov

5. **ScienceOrganizer:** The ScienceOrganizer system provides distributed scientific teams with access to a centralized Web-based project information repository. In the lab, the field, or the office, ScienceOrganizer serves as a collection point for scientific data, notes, documents, images and other scientific records generated by project participants and the scientific instruments they operate. These information resources are "threaded" together using a unique hyperlinking structure that captures semantic relationships among stored information resources. Automated inference techniques are employed to augment the knowledge stored in the repository. ScienceOrganizer serves as a type of "project memory", archiving the scientific processes and products of the team. The system is in pilot usage by teams of astrobiologists in the NASA Astrobiology Institute (see #28 below).

   Classification: repository system; organizational memory system; knowledge modeling/representation system

Deployment Status: deployed

Funding Source: CICT, NAI, ECS

URL: http://sciencedesk.arc.nasa.gov/organizer

Point of Contact: Richard Keller, rkeller@arc.nasa.gov

6. **DARWIN:** DARWIN provides remote integrated access to large volumes of aviation test data generated by advanced wind-tunnel instrumentation suites and sophisticated numerical airflow simulation codes. Users can browse through the tests or query the DARWIN database for specific information. Data from wind tunnel tests in progress can be viewed on a "live" screen that updates its displays in near real time to reflect the most recent results. Both live and archival data are displayed in user-configurable tables and plots. DARWIN has been popular with engineers for its live monitoring capabilities and its cross-test comparison features. The system is being applied to other data domains, including geological data and mission operations data (see #20 below).

   Classification: repository system

   Deployment Status: deployed

   URL: http://www.darwin.arc.nasa.gov/docs/

   Point of Contact: Joan Walton, jdwalton@mail.arc.nasa.gov

7. **PDARS:** The Performance Data Analysis and Reporting System (PDARS) is a repository system for air traffic control (ATC) data. Information, including radar track data, is routinely collected from air traffic control centers and then processed and analyzed to produce quantitative performance measures for ATC management. PDARS helps identify operations problems and facilitates data analysis. PDARS data can be mined to determine patterns and trends over time. Periodic face-to-face meetings of PDARS users encourage information-sharing across ATC centers. The PDARS system is being developed by the ATAC Corporation with funding from the NASA and the FAA.

   Classification: repository system; knowledge mining system

   Deployment Status: deployed

   Funding Source: AvSP, FAA

   Point of Contact: Irv Statler, istatler@mail.arc.nasa.gov

8. **APMS:** The Aviation Performance Measuring System (APMS) is an airline-based repository and analysis system for digital flight data. APMS stores up to several thousand parameters per flight, recorded at sampling rates of up to 8 Hz. Data is collected on a routine basis during commercial flights on aircraft equipped with secondary (i.e., non-crash) digital flight data recorders. APMS includes tools for searching, mining, and analyzing the recorded flight data, for animating flights, and for generating management reports. Insights based on APMS data are used to improve operations, safety, and training within the host airline. The APMS system is being co-developed by NASA and Battelle Memorial Institute.

   Classification: repository system; knowledge mining system

   Deployment Status: deployed

   Funding Source: AvSP

   URL: http://human-factors.arc.nasa.gov/ihs/activities/apms.gif

   References: (Chidester, 2001)

   Point of Contact: Tom Chidester, tchidester@mail.arc.nasa.gov

9. **Virtual Iron Bird:** This system incorporates a repository of International Space Station engineering components encompassing component schematics, CAD drawings, and engineering specifications. The components can be viewed and manipulated using a 3-D graphical browsing tool, and placement within the Station environment can be graphically simulated. The repository is designed to serve as an astronaut training tool and a mission operations tool.

   Classification: repository system

Deployment Status: prototype

Funding Source: CICT

URL: http://ssrl.arc.nasa.gov/

Point of Contact: Robert Mah, rmah@mail.arc.nasa.gov

10. **ASRS:** The Aviation Safety Reporting System (ASRS) is a repository of aviation safety incident reports. Aviation personnel, including pilots, air traffic controllers, flight attendants, mechanics, and ground personnel voluntarily file ASRS reports when they are involved in or observe an incident or situation in which aviation safety was compromised. In exchange for reporting, the filer gains immunity from prosecution for unintentional violations of federal aviation statutes. (Such violations occur in less than half of reported cases.) ASRS data is used to monitor and improve aviation safety by providing feedback to personnel involved in setting aviation policy and procedures within the government and the private sector. ASRS includes a strong outreach and education component, featuring a monthly newsletter entitled CALLBACK (see #20 below). The ASRS system is funded largely by the FAA, with subsidiary funding by NASA. NASA provides management oversight and direction for ASRS, which is operated under contract to Battelle Memorial Institute.

    Classification: repository system; lessons learned system

    Deployment Status: deployed

    Funding Source: FAA, AOS, AvSP, CICT

    URL: http://asrs.arc.nasa.gov/

    Point of Contact: Linda Connell, lconnell@mail.arc.nasa.gov

11. **WebTagger:** The WebTagger is a collaborative bookmarking system featuring advanced adaptive indexing and search capabilitites. WebTagger serves as a shared Web bookmark repository for users within a workgroup. Users can store their bookmarks (or "favorites") on a remote server and index them with topical categories. The bookmarks and categories can be shared across different workgroups. WebTagger features an adaptive retrieval mechanism that allows users to provide relevance feedback on the utility of shared bookmarks.

    Classification: repository system; indexing and search system

    Deployment Status: prototype; inactive

    URL: http://ic.arc.nasa.gov/projects/aim/previous.html

    References: (Keller, Wolfe, Chen, Rabinowitz, & Mathe, 1997)

    Point of Contact: Richard Keller, rkeller@arc.nasa.gov

12. **Concept Maps:** Concept maps are visual knowledge representations, useful for organizing and modeling knowledge. Invented by educator Joseph D. Novak at Cornell University, concept maps (Novak, 1977) have been highly successful in educational and public outreach settings. At Ames in particular, concept maps have bees created for astrobiology, and are the basis of a large collection of information about Mars -- text, images, video clips, web links, etc. -- developed by the Center for Mars Exploration (CMEX). These concept maps are delivered on the Web and on a CD ROM popular among teachers and featured in classroom settings at various levels. In a concept map, pairs of concepts are displayed and visually linked together with phrases expressing relationships between the concepts. The Institute for Human and Machine Cognition at the University of West Florida has developed software that allows users to construct, navigate, share, and criticize knowledge models represented as concept maps (Cañas, Ford, Brennan., Reichherzer., & Hayes, 1995; Cañas, Leake, & Wilson, 1999). By allowing linking from concepts to related material on the Internet, the software also allows the concept maps to be used as an innovative form of Web browser.

    Classification: organizational memory system; knowledge modeling/representation system

    Deployment Status: deployed

    Funding Source: CMEX

    URL: http://cmex.arc.nasa.gov/cmaps

Point of Contact: Jeffrey Scargle, jeffrey@cosmic.arc.nasa.gov

Knowledge Augmentation Systems

13. **Air Passenger Screening:** In response to increased aviation security concerns, both commercial and government-developed knowledge management software is being used to monitor news feeds, gather and correlate information from multiple websites and databases, and mine passenger data for the purpose of passenger and flight threat assessment. Additional information from airport, government, and commercial databases will be fused with passenger reservation records and analyzed for both safe and suspicious patterns.

    Classification: knowledge mining system; knowledge integration system

    Deployment Status: prototype

    Funding Source: CICT

    Point of Contact: Tom Hinke, thinke@mail.arc.nasa.gov

14. **QUORUM Perilog:** Perilog is a suite of tools for mining information from unstructured text documents (e.g., reports, narratives). Perilog was originally developed to help mine the ASRS database (see #10 above) and explore relationships across aviation incident reports and between incidents and accidents. Perilog provides analysis, relevance ranking, search, phrase mining, and modeling capabilities. The system's general techniques apply to arbitrary sequenced data (e.g., numeric sequences), not simply to text.

    Classification: knowledge mining system; indexing and search system

    Deployment Status: deployed

    Funding Source: AvSP

    URL: http://human-factors.arc.nasa.gov/IHpublications/mcgreevy/ASRS.search

    References: (McGreevy, 2001)

    Point of Contact: Michael McGreevy, mmcgreevy@mail.arc.nasa.gov

15. **ADIS:** The Aviation Data Integration System (ADIS) integrates various sources of aviation data to provide enhanced contextual information for aviation safety analysts. The sources of data include recorded digital flight data, weather data, airport condition information, radar data, and runway visibility data. By combining these sources, ADIS enables safety analysts to retrospectively understand the conditions under which anomalous flight events were observed in recorded data. Results of these analyses can be used to improve airline training, maintenance, and operations procedures.

    Classification: knowledge integration system

    Deployment Status: prototype

    Funding Source: AvSP

    URL: http://ic.arc.nasa.gov/projects/adip

    Point of Contact: Deepak Kulkarni, dkulkarni@mail.arc.nasa.gov

16. **MPRS:** The Program Management Progress Reporting System (MPRS) is Web-based system designed to track NASA program and project milestones. MPRS provides managers with timely information about the state of program and project resources, and provides visualization and reporting tools to support analysis and decision-making. The system allows users to create and update milestones, to search within the management data, and to generate Web-based reports. MPRS supports the hierarchical NASA program and project management structure consisting of nested program element levels. MPRS usage is being piloted by the Engineering for Complex Systems program.

    Classification: knowledge integration system

    Deployment Status: deployed

    Funding Source: ECS

    Point of Contact: David Maluf, dmaluf@mail.arc.nasa.gov

17. **ISTKMS:** The Information Sciences and Technology Knowledge Management System (ISTKMS) is an integrative Web-based repository containing information about ongoing projects within the Information Sciences and Technology Directorate (Code I) at Ames Research Center. ISTKMS integrates a number of different databases containing project, personnel, and funding information to provide a unified view of ongoing research projects within the Directorate. The system is intended to assist management in performing analyses of current capabilities and making strategic decisions about resources and future directions. Individual project leads will be responsible for ensuring that the project-specific information in ISTKMS is accurate and up-to-date.

    Classification: knowledge integration system

    Deployment Status: prototype

    Funding Source: IST

    URL: http://istkms.arc.nasa.gov/

    Point of Contact: Michael Freeman, mfreeman@mail.arc.nasa.gov

18. **Aerospace Extranet:** Aerospace Extranet (AEN-1) is a mediated architecture for transforming heterogeneous legacy data into meaningful integrated information. AEN-1's middleware integration technology is based on Common Object Request Broker Architecture (CORBA) standards, which mediate between user applications and independent data sources. These data sources can reside on multiple, heterogeneous computer platforms and may be stored in a variety of formats, such as relational databases, flat files, and object-oriented databases. AEN-1 creates a "virtual object database" so that user applications view the disparate data sources as though they were stored within a single, integrated database. In addition, AEN-1 provides advanced data instance integration capabilities, such as object unification and fusion, abstraction, aggregation, and data and schema translation.

    Classification: knowledge integration system, networks

    Deployment Status: deployed

    Funding Source: AvSP

    References: (Maluf & Tran, 2001)

    Point of Contact: David Maluf, dmaluf@mail.arc.nasa.gov

19. **Aviation Data Registry:** The International Aviation Data Registry (AvDR) is a comprehensive web-based repository of standard aviation taxonomies and related metadata. This prototype supports the standards-setting process for international aviation data by recording and disseminating data standards across aviation information system developers and organizations. AvDR enables users to learn about the existence of aviation data standards, to understand aviation metadata (such as data element definitions, formats, etc.), and to download the standards for use in their own local system. AvDR was developed in collaboration with representatives from the Commercial Aviation Safety Team (CAST) and the International Civil Aviation Organization (ICAO) Common Taxonomy Team.

    Classification: descriptive metadata system; standards development

    Deployment Status: prototype; inactive

    URL: http://dataregistry.aen.nasa.gov/AvDR/TaxonomyNames.html

    Point of Contact: David Maluf, dmaluf@mail.arc.nasa.gov

Knowledge Dissemination Systems

20. **MER CIP:** Collaborative Information Portal (CIP) is being constructed to provide an integrative, configurable view of mission operations and mission status information to support the upcoming Mars Exploration Rover (MER) mission in 2003. The system provides dynamic content from multiple mission data sources (e.g., mission documents, status messages, command sequences, rover images), and makes it available via a single unified Web portal interface. The goal of CIP is to facilitate MER mission management by providing a supplementary information source capable of presenting key mission information in a single interface.

Although CIP will display certain information to all users, different classes of users will have different datasets available for customized views, depending upon their mission roles.

Classification: portal system

Deployment Status: prototype

Funding Source: CICT

Point of Contact: John Schreiner, jschreiner@mail.arc.nasa.gov

21. **CALLBACK**: CALLBACK is an aviation safety newsletter based on lessons learned from ASRS reports (see #10 above). The newsletter is widely read in the aviation community, and is available in paper form and online. CALLBACK is mailed to subscribers, sent to aviation organizations for distribution, and sent to all Aviation Medical Examiners for display in their offices. Considerable editorial and production effort is put into making the newsletter interesting, relevant, and readable. CALLBACK serves as a key component of the ASRS education and outreach mission. The FAA provides the majority of funding for CALLBACK.

    Classification: newsletter

    Deployment Status: deployed

    Funding Source: FAA, AOS, AvSP, CICT

    URL: http://asrs.arc.nasa.gov/

    Point of Contact: Linda Connell, lconnell@mail.arc.nasa.gov

22. **DIAMS:** Distributed Information Agents for information Management and Sharing (DIAMS) is an agent-based information-sharing system constructed as a successor to the WebTagger system (see #11 above). As with WebTagger, the application domain involves the sharing of Web bookmarks. DIAMS provides a framework by which intelligent agents can search distributed bookmark repositories to locate URLs of potential interest based on user-defined categories. Users query the system using combinations of topical categories. The agents must translate among the categories defined for each separate repository to find potentially-relevant URLs across the distributed set of repositories.

    Classification: agent system; indexing and search system

    Deployment Status: prototype; inactive

    URL: http://ic.arc.nasa.gov/projects/aim/current.html

    References: (Chen, Wolfe, & Wragg, 2000)

    Point of Contact: Shawn Wolfe, shawn@email.arc.nasa.gov

23. **Brahms:** Brahms is a multi-agent simulation environment designed to model and analyze work practice. The models of organizational work practice developed using Brahms can assist in designing and implementing workflow and knowledge management systems. Developing a Brahms model is a unique method of recording and documenting the work practices of NASA personnel, including astronauts, mission operations staff, scientists, engineers, and others. Brahms' representation language is designed to enable modeling of human (and intelligent agent) activities, including communication, collaboration, and perception. Brahms work practice modeling and simulation is being used to support human-centered software design and technology deployment in unique NASA contexts, including Mars exploration missions.

    Classification: agent system; knowledge modeling/representation system

    Deployment Status: deployed

    Funding Source: CICT

    URL: http://www.agentisolutions.com/home.htm

    References: (Clancey, Sachs, Sierhuis, & van Hoof, 1998; Sierhuis, 2001)

    Point of Contact: Maarten Sierhuis, msierhuis@mail.arc.nasa.gov

24. **Office of the Future:** Office of the Future is a technology concept melding remote collaboration, visualization, virtual environments, and high-speed networks. The idea is to create an advanced computational environment to support collaborative aerospace engineering and science applications using a very high bandwidth (622 Mbps) network. This environment would be used to demonstrate high-fidelity immersive virtual environments across long distances. The Office of the Future would enable policy-makers and managers at NASA Headquarters to experience Ames' advanced virtual technologies without requiring a personal visit.

    Classification: collaboration and meeting support system

    Deployment Status: concept development

    Point of Contact: Ken Freeman, kfreeman@mail.arc.nasa.gov

25. **MERboard:** The MERboard consists of a large touch-sensitive plasma screen display plus software to facilitate group collaboration, information sharing, and information distribution in meeting rooms and other spaces where people congregate and the board is installed. The MERboard concept was inspired by IBM's BlueBoard system (Russell & Gossweiler, 2001), but is being redesigned and reimplemented to support the needs of the Mars Exploration Rover (MER) mission. MERboard will be used as part of MER operations and science team meetings, functioning as an electronic flipchart to support display and annotation of Mars images, operations data, and other mission information. Meeting participants will be able to save and disseminate annotated material, sketches, URLs and other information to participants and other people not present at the meeting. The information will also be accessible at any MERboard installation. MERboard also features application-sharing and Web browser functionality.

    Classification: collaboration and meeting support system

    Deployment Status: prototype

    Funding Source: CICT

    Point of Contact: Jay Trimble, jtrimble@mail.arc.nasa.gov

Knowledge Infrastructure Systems

26. **Information Power Grid:** The Information Power Grid (IPG) is NASA's high performance computational grid. Computational grids are persistent networked environments that integrate geographically distributed supercomputers, large databases, and high-end instruments. The IPG provides essential networking capability to support next-generation knowledge management applications, such as massively distributed scientific data mining. IPG is a collaborative project with NASA Glenn, NASA Langley, the San Diego Supercomputer Center, and the National Center for Supercomputer Applications.

    Classification: networks

    Deployment Status: prototype

    Funding Source: CICT

    URL: http://www.ipg.nasa.gov/

    Point of Contact: William Thigpen, thigpen@nas.nasa.gov

27. **SAFE:** The Secure Advanced Federated Environment (SAFE) is an infrastructure solution to the problems associated with mission-critical distributed computing and collaboration. Apart from simple Web-based applications, it is usually difficult to deploy secure distributed applications across NASA centers and collaborating partners. Each installation has its own security infrastructure and therefore customized solutions need to be developed on a case-by-case basis. SAFE is developing a security architecture that crosses enterprise boundaries in a standardized fashion, thereby creating a multi-use environment for distributed software applications. This is cross-center collaboration with JPL, MSFC, LaRC, JSC, and KSC.

    Classification: networks; security

    Deployment Status: prototype

    Funding Source: CICT, ECS

    Point of Contact: Helen Stewart, hstewart@mail.arc.nasa.gov

28. **NASA Astrobiology Institute:** The NASA Astrobiology Institute (NAI) is a large-scale "virtual institute" focused on facilitating multidisciplinary astrobiology science within NASA and associated university and industrial research communities. As part of its mission, the NAI is attempting to foster a knowledge-sharing astrobiology culture using both technological and non-technological means. As such, the NAI serves as a testbed within which new scientific collaboration and knowledge management practices can be tested and deployed. For example, NAI members have field-tested Ames-developed KM tools such as Postdoc (see #3 above) and ScienceOrganizer (see #5 above). NAI is planning to deploy desktop conferencing, virtual meeting tools, and other collaborative technologies over time.

    Classification: methods

    Funding Source: NAI

    URL: http://nai.arc.nasa.gov

    Point of Contact: Lisa Faithorn, lfaithorn@mail.arc.nasa.gov

29. **Human-Centered Technology Studies:** Ames is a proponent of empirical study and analysis in the design and evaluation of knowledge management systems. Ames personnel employ human-centered techniques and methodologies to understand knowledge management requirements, evaluate impacts resulting from new technology introduction or changes in work process, and contribute to the design of new tools. The analysis techniques employed include ethnographic methods such as field study, interview, observation, and video analysis. Ames has conducted various technology studies within the agency, including an evaluation of the information flow within the Space Shuttle Problem Reporting and Corrective Action (PRACA) database system; an evaluation of information architectures, communication patterns, and work practices within both the Space Shuttle and International Space Station mission control centers; a study of ground based airline operations and the factors contributing to airline flight delays; and participation in the design of work processes related to information-sharing, communication, and round trip data tracking for the Mars Exploration Rover mission. In all cases, these studies have produced specific technology design and implementation recommendations.

    Classification: methods

    Funding Source: CICT, ECS

    Point of Contact: Charlotte Linde, clinde@mail.arc.nasa.gov

4. Conclusions

In this chapter, we have reviewed ongoing research and development in knowledge management at NASA Ames Research Center. The systems described were developed for a wide variety of programs, projects, and missions within the Agency, including International Space Station, Space Shuttle, Mars Exploration Rover, the national aviation system, the Astrobiology Institute, mission safety assurance, earth sciences, space sciences, and others. Given NASA's continuing demonstrated need, this broad deployment of targeted knowledge management systems for Agency programs and projects is bound to continue and evolve, building upon the success of these efforts. Ames' challenging role is to conduct research in knowledge management, anticipate NASA's needs, and develop new techniques and methodologies to satisfy NASA's future requirements for KM.

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